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Cues of Fatigue: Effects of Sleep Deprivation on Facial Appearance

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Study Objective: To investigate the facial cues by which one recognizes that someone is sleep deprived versus not sleep deprived.
Design: Experimental laboratory study.
Setting: Karolinska Institutet, Stockholm, Sweden.
Participants: Forty observers (20 women, mean age 25 ± 5 y) rated 20 facial photographs with respect to fatigue, 10 facial cues, and sadness. The stimulus material consisted of 10 individuals (five women) photographed at 14:30 after normal sleep and after 31 h of sleep deprivation following a night with 5 h of sleep.
Measurements: Ratings of fatigue, fatigue-related cues, and sadness in facial photographs.
Results: The faces of sleep deprived individuals were perceived as having more hanging eyelids, redder eyes, more swollen eyes, darker circles under the eyes, paler skin, more wrinkles/fine lines, and more droopy corners of the mouth (effects ranging from b = +3 ± 1 to b = +15 ± 1 mm on 100-mm visual analog scales, $P < 0.01$). The ratings of fatigue were related to glazed eyes and to all the cues affected by sleep deprivation ($P < 0.01$). Ratings of rash/eczema or tense lips were not significantly affected by sleep deprivation, nor associated with judgements of fatigue. In addition, sleep-deprived individuals looked sadder than after normal sleep, and sadness was related to looking fatigued ($P < 0.01$).
Conclusions: The results show that sleep deprivation affects features relating to the eyes, mouth, and skin, and that these features function as cues of sleep loss to other people. Because these facial regions are important in the communication between humans, facial cues of sleep deprivation and fatigue may carry social consequences for the sleep deprived individual in everyday life.
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INTRODUCTION

Humans use a wide range of different cues to communicate how they feel and to read the inner state of other individuals.[1] The face is the primary source of information in social perception.[2] Through the use of facial muscles and varying blood flow, humans express a variety of emotional and motivational states such as anger, fear, sadness, happiness, and shame, which strongly influence social interaction.[3] Fatigue can be regarded as a motivational drive to rest,[4] and it is likely that this drive can be perceived and understood through facial cues[5] in a manner similar to emotional expressions. In everyday life, we commonly hear statements such as "you look tired," "I didn't sleep well, hence the dark circles under my eyes," or "I need to get my beauty sleep." In a recent study, we confirmed that sleep deprived people are perceived as more fatigued, less attractive, and even less healthy than when they are rested, confirming the colloquial notion of beauty sleep and suggesting a role of sleep history in social interactions.[5] However, it is not known which facial cues actually shape these judgments. The goal of the current study was to assess these cues. To enhance our control over stimulus qualities and enable comparisons to earlier work, we used the same stimulus material as in the previous study on beauty sleep[5] but with new raters.

The question of how facial features signal fatigue has received little scientific attention. An exception is research on driver fatigue, where observers can be trained to reliably estimate a person's sleepiness based on eyelid closure, facial expressions, and body movements.[6] These studies show that long eyelid closures are judged as indicators of sleepiness,[7] which is consistent with the fact that when told to judge the fatigue of photographed faces, people spend most of their time looking at the eye region.[8] Indeed, looking fatigued has been assumed to be connected with cues related to the eyes[9,10] but this has not previously been scientifically studied. Researchers sometimes ask people to evaluate whether someone in a photograph is fatigued or sleepy without further explanation as to what these states actually look like.[8,11]

In addition to being crucial in conveying behavioral intentions and emotional state,[3] facial expressions may also reveal nonverbal cues of the person's level of fatigue. The goal of the current study was to investigate the facial cues that signal to observers that a sleep deprived person is fatigued. Another goal was to describe these effects on an individual level to indicate uniformity, since this is a novel area of study in the field. Because there may be an overlap between cues of fatigue and expression of sadness, we also investigated whether looking sad was related to sleep deprivation and looking fatigued. The study consisted of three parts: the first obtained photographs of faces taken after normal sleep and sleep deprivation,[5] the

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second collected candidate cues relating to fatigue. In the third part, participants rated the photographs with respect to nine candidate cues likely to relate to fatigue, one control cue, and sadness. We thus hypothesized that sleep deprivation and looking fatigued would relate to nine of the facial cues included, as well as looking sad.

METHOD

Part 1 (Photographs)

Twenty photographs were taken from a sleep deprivation study where 23 individuals were photographed on two separate occasions in a balanced design: after 8 h of normal sleep, and after 31 h of sleep deprivation following 5 h of sleep the night before.[5] The photographs were taken in the laboratory at 14:30 on both occasions, to control for location and time-of-day effects. Sleep periods occurred in the participants' own homes and were verified with sleep diaries and short message system (SMS), whereas sleep deprivation was in a controlled laboratory setting (see Axelsson et al.[5] for more details on sleep data). Exclusion criteria, assessed through a screening questionnaire, were poor general health, sleep disturbances or abnormal sleep requirements, psychiatric disorders, and smoking, as well as working night shifts or traveling over more than two time zones within the previous 3 months. In the original study, all 23 participants were rated on fatigue and for the current study the photographs of five men and five women (all Caucasian, ages 19-32 y, mean age 24 ± 4 y) were randomly chosen, after three individuals with a low variation of rated fatigue had been removed from the study. Photographs of 10 individuals were used to restrict test duration to less than 35 min. The participants had been kept indoors for 2 h before being photographed to avoid potential effects of daylight. At 14:30 (± 30 min) a series of five to six photographs (NIKON D80, Nikon Corp., Tokyo, Japan; resolution: 3,872 × 2,592 pixels) were taken in a well-lit room (900 lx) under constant, nonflash conditions. Participants wore no makeup, wore their hair loose (combed off the face if long), and were instructed to look straight into the camera and have a neutral facial expression. They had similar cleaning/shaving procedures during both conditions and were not informed about how their photographs would be assessed. The most representative photograph from each photo shoot (the photograph of the five to six that diverted the least from the others) was chosen by a naïve rater, resulting in two photographs of each individual—one from each condition.

Part 2 (Cues)

We asked 50 students and 10 sleep researchers (from several countries, including Sweden, the Netherlands, and Australia) to list cues they associate with looking fatigued. This resulted in a list of 53 cues, of which 21 were related to behaviors, that in a second step were rated by another 61 people and the same 10 sleep researchers (mean age 30 ± 11 y for the entire group) with respect to likelihood of appearing on a fatigued person (with the possible answers *yes* or *no*). We excluded overt behaviours such as yawning, as well as cues related to being unkempt. The final list consisted of the six cues most commonly believed to relate to fatigue: hanging eyelids, red eyes, swollen eyes, glazed eyes, dark circles under the eyes, and pale skin (88-100% answered *yes*). Most of these cues concern the eyes, and three additional cues were chosen to better represent changes of the skin (wrinkles around the eyes [44%] and rash/eczema [35%]) and the mouth (droopy corners of the mouth [70%]). We also included a design control variable, tense lips, which was not included in the original list and had no expected association with fatigue. Sadness was added because some of the cues (e.g., droopy corners of the mouth and glazed eyes) may overlap with expressions of sadness.[12] Thus, the photographs were rated on 10 facial cues, fatigue, and sadness.

Part 3 (Ratings)

Forty participants (20 women) with a mean age of 25 y (Standard Deviation ± 5, age range 18-40 y) were recruited through information notices posted at the Karolinska Institutet campus and the Karolinska University Hospital in Stockholm, Sweden. The participants observed all 20 facial photographs from part 1 and rated them with respect to all 12 aspects (10 facial cues, sadness, and fatigue), without being informed about the reasons for the study. Thus, each observer rated 240 photographs taken after normal sleep and 240 taken after sleep deprivation. The observers gave informed consent after the protocol had been fully explained and they were compensated for their participation. The study was approved by the Regional Ethics Committee in Stockholm.

The 20 photographs were presented in a pseudorandomized order (the same individual was never shown with fewer than two other individuals in between) on a 12-inch computer screen and rated with respect to one facial cue at a time. After every 10 photographs a brief intermission occurred, including a working memory task lasting 18 sec to prevent the memorization of previous ratings. Each photograph was shown at a fixed interval of 5 sec and was rated on a 100- mm visual analog scale (VAS, with a midpoint anchor at 50 mm) according to the following cues: dark circles under the eyes (no dark circles-very dark circles), red eyes (not at all red-very red), glazed eyes (not at all glazed-very glazed), hanging eyelids (not at all hanging-very hanging), swollen eyelids (not at all swollen-very swollen), pale skin (not at all pale-very pale), wrinkles/fine lines (no wrinkles/fine lines-a lot of wrinkles/fine lines), rash/eczema (no rash/eczema at all-a lot of rash/eczema), corners of the mouth pointing down (not at all-very much), tense lips (not at all tense-very tense), fatigue (not at all fatigued-very fatigued) and sadness (not at all sad-very sad).

Statistical Analyses

Data were analyzed using multilevel mixed effects linear regression with two crossed independent random effects accounting for random variation between observers (rating the photographs) and indiviudals (in the photographs), using the xtmixed procedure in STATA 11.1 (STATACorp, College Station, Texas, USA). The fixed effects can be thought of as the typical person in the normal sleep condition (intercept) and the effect/slope (*b*) of sleep deprivation for this person (as compared with normal sleep). The random effects describe the variability related to what extent each observer varies from the average of all observers, and the extent to which each face varies from the average of all faces. The analyses of the relationship between fatigue and different cues include all photographs.

Table 1—Facial cues affected by sleep deprivation, and the relationships between facial cues and observer rated fatigue

	Baseline		Sleep deprivation			vs rated fatigue of the photographs		
	constant	SE	*b*	SE	P value	*b*	SE	P value
Observer rated fatigue (mm)	46.3	2.6	8.5	1.3	< 0.001			
Eye-related cues								
Hanging eyelids (mm)	45.8	4.7	14.8	1.4	0.001	0.4	0.0	0.001
Red eyes (mm)	38.3	4.4	5.1	1.2	0.001	0.2	0.0	0.001
Swollen eyes (mm)	44.6	4.1	10.9	1.3	0.001	0.3	0.0	0.001
Glazed eyes (mm)	61.1	2.9	-1.7	1.2	0.147	0.2	0.0	0.001
Skin-related cues								
Dark circles under eyes (mm)	45.1	3.3	7.2	1.1	0.001	0.3	0.0	0.001
Pale skin (mm)	56.2	4.9	2.9	1.1	0.009	0.1	0.0	0.003
Wrinkles/lines around the eyes (mm)	35.6	3.7	7.4	1.1	0.001	0.2	0.0	0.001
Rash/eczema (mm)	49.2	5.2	0.8	1.1	0.454	0.0	0.0	0.315
Other cues and sadness								
Droopy corners of mouth (mm)	29.3	3.1	10.7	1.1	0.001	0.3	0.0	0.001
Tense lips (control variable, mm)	44.1	3.3	0.5	1.3	0.680	0.1	0.0	0.131
Sadness (mm)	42.0	3.4	10.8	1.3	0.001	0.4	0.0	0.001

All cues and fatigue were rated on Visual Analogue Scales (VAS, 100mm) by 40 observers of 20 photographs (the number of observations range from 778 to 800 for all analyses). Baseline (constants) represents the observer rated level of each cue on the 10 photographs taken after baseline sleep. Sleep deprivation represents the fixed effect (*b*) of sleep deprivation vs. baseline sleep (the coefficient reported is the linear effect in mm for each mm on the VAS). SE, standard error.

The illustrations of the relationships in the figures represent the average observer, with the variation between observers removed by means of Empirical Bayes estimates. The significance level was set to 0.01 to minimize the risk of making type 1 errors. To describe the individual reaction patterns in response to sleep deprivation, we report the significant effects that followed the hypothesis of being worse with sleep deprivation in Table 2, P-level set to 0.05 in this descriptive part.

RESULTS

Sleep Deprivation

Compared with after a night of normal sleep, sleep deprived individuals were rated as looking more fatigued ($b = +9 \pm 1$ mm on VAS, $P < 0.01$), having more hanging eyelids ($b = +15 \pm 1$ mm, $P < 0.01$), redder eyes ($b = +5 \pm 1$ mm, $P < 0.01$), more swollen eyes ($b = +10 \pm 1$ mm, $P < 0.01$), darker circles under the eyes ($b = +7 \pm 1$ mm, $P < 0.01$), paler skin ($b = +3 \pm 1$ mm, $P < 0.01$), more wrinkles and fine lines around the eyes ($b = +7 \pm 1$ mm, $P < 0.01$), the corners of the mouth as being more droopy ($b = +11 \pm 1$ mm, $P < 0.01$) and more sad ($b = +11 \pm 1$ mm, $P < 0.01$), see Table 1. Sleep deprivation did not significantly affect the level of glazed eyes ($b = -2 \pm 1$ mm, $P = 0.15$), rash/eczema ($b = +1 \pm 1$ mm, $P = 0.45$) or tense lips ($b = +1 \pm 1$ mm, $P = 0.68$).

Observer-Rated Fatigue

Ratings of someone's fatigue were positively correlated with ratings of hanging eyelids, swollen eyes, red eyes, glazed eyes, dark circles under the eyes, wrinkles/fine lines, and corners of the mouth pointing downward ($P < 0.01$ for all mentioned factors), see Table 1. Fatigue was not significantly related to rash/eczema ($P = 0.32$) or tense lips ($P = 0.13$). This means that all cues pertaining to the eyes and the skin were significantly related to looking fatigued (Figure 1), with the exception of rash/eczema. With respect to mouth-related cues, ratings on droopy corners of the mouth, but not tense lips (the control variable), were related to ratings on fatigue. In addition, ratings on sadness were associated with ratings of fatigue ($P < 0.01$). For each mm of change in ratings of droopy corners of the mouth, ratings of sadness changed $+0.3 \pm 0$ mm, $P < 0.001$.

Individual Differences in the Effect of Sleep Deprivation

Analyses on the individual level showed that seven of the 10 individuals were judged to look significantly more fatigued when sleep deprived (Table 2). Hanging eyelids was the cue most generally affected by sleep deprivation (nine individuals were rated as having significantly more hanging eyelids). For the other cues, the following numbers of individuals were significantly worse during sleep deprivation: swollen eyes (six individuals), dark circles under the eyes (six), pale skin (six), fine lines and wrinkles around the eyes (six), droopy corners of the mouth (six), red eyes (four), rash/eczema (three), tense lips (three), and glazed eyes (zero). In addition, seven participants were judged to look sadder while sleep deprived. With respect to effects against the hypotheses, the following number of individuals received significantly lower ratings on these cues during sleep deprivation: glazed eyes (two), rash/eczema (three), and tense lips (one), none of which were significantly related to sleep deprivation when analyzed as a group.

Separate analyses of the effects of sleep deprivation for men and women showed similar effects for both sexes as for the group as a whole (Table 2). Sleep deprivation in both men and women was related to looking significantly more fatigued, having more hanging eyelids, redder eyes, more swollen eyes, darker circles under the eyes, more wrinkles/lines around the eyes, more droopy corners of the mouth, and being perceived as more sad. The only difference was that women were not

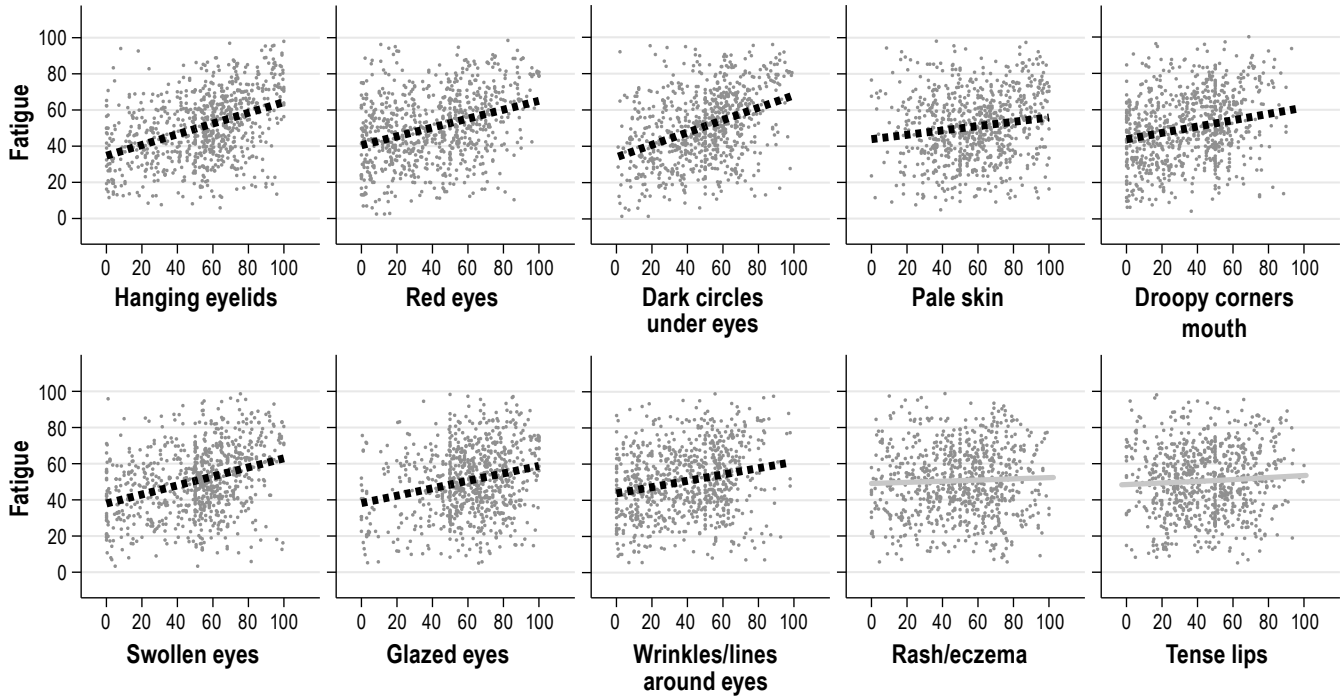

Figure 1—Relationships between rated fatigue and facial cues. The figure illustrates how high fatigue ratings were related to high ratings on hanging eyelids, red eyes, swollen eyes, and glazed eyes. High ratings of fatigue were also related to dark circles under the eyes, pale skin, and wrinkles/fine lines around the eyes, but not rash/eczema. In addition, high ratings of fatigue relate to droopy corners of the mouth and sadness, but not tense lips. The plots consist of 778-800 ratings each (40 observers rated 20 photos) on 100 mm visual analogue scales. The relationships are based on the models presented in Table 1, with the variation between observers removed (by means of Empirical Bayes estimates). Thus, all observers have been adjusted (in level) to represent an average observer.

Table 2—Fatigue and facial cues affected by sleep deprivation for each of the 10 photographed participants. Significances are marked for cues being adversely affected by sleep deprivation

	Fixed effect of sleep deprivation												No. of individuals worse with SD
	id 1	id 2	id 3	id 4	id 5	id 6	id 7	id 8	id 9	id 10	women	men	
Sex	w	w	w	w	w	m	m	m	m	m			
Observer-rated fatigue (mm)	20***	13***	8*	7*	9**	6*	-3	3	1	21***	11***	5***	7
Eye-related cues													
Hanging eyelids (mm)	40***	14***	15***	11**	24***	9**	8**	13***	0	15***	21***	9***	9
Red eyes (mm)	10**	19***	0	1	-3	5	2	11*	1	6*	5***	5***	4
Swollen eyes (mm)	21***	5	18***	1	20***	10***	3	20***	-3	14***	13***	9***	6
Glazed eyes (mm)	-2	1	-2	-8†	-3	-2	-3	-5†	2	4	-3	-1	0
Skin-related cues													
Dark circles under eyes (mm)	19***	14***	9*	3	0	7*	3	8**	5	5*	9***	6***	6
Pale skin (mm)	-3	3	0	9**	2	10**	9**	20***	11***	9**	2	4*	6
Wrinkles/lines around the eyes (mm)	19***	1	11***	4	9**	1	7*	14***	8*	-1	9***	6***	6
Rash/eczema (mm)	-8†	4	6**	6	-13†	3	4	-9†	11***	9**	0	3	3
Other cues and sadness													
Droopy corners of mouth (mm)	43***	15***	8*	0	18***	3	-2	4	6**	13**	17***	5**	6
Tense lips (mm)	20***	4	0	-35†	0	11***	-1	13***	1	-7	-2	3*	3
Sadness (mm)	34***	8**	9***	0	13***	4	-2	6	5*	30***	13***	8***	7

Each analysis consists of 78 to 80 ratings (two photographs of each individual rated by 40 observers). The 10 individuals were photographed after normal sleep (8 h of sleep + 7 h of wakefulness) and after sleep deprivation (5 h of sleep + 31 h of wakefulness). The fixed effect (coefficient) of sleep deprivation represents the fixed effect of sleep deprivation versus baseline sleep (the "effect" (coefficient) reported is the linear effect in mm for each mm on the VAS). id, individual; SD, sleep deprivation; m, man; w, woman. *P < 0.05, **P < 0.01, ***P < 0.001 for effects following the hypothesis of being increased with sleep deprivation, †P < 0.05 for effects against the hypothesis.

perceived as significantly paler, as opposed to both the men and the group as a whole. In addition, men showed a tendency to have more tense lips (the control variable) when sleep deprived ($P = 0.04$), something that was not significant for women or the group as a whole.

DISCUSSION

Our findings show that sleep deprivation affects a number of facial characteristics that observers relate to fatigue. Sleep deprivation is thus readily observable from a set of facial cues. It seems that many of the colloquial cues, such as droopy/hanging eyelids, red eyes, dark circles under the eyes, and pale skin, are indicative of both sleep deprivation and looking fatigued. In addition, there was a correlation between looking fatigued and looking sad. With the exception of glazed eyes, all of the cues that were correlated with looking fatigued were also affected by sleep deprivation.

It has been argued that face perception is the most developed visual perceptual skill in humans, partially due to it having its own specialized neuronal network.[2] The face serves a key role in social perception, affecting people's judgments of everything from trustworthiness and aggressiveness to competence and likeability in as little as 100 ms.[13] It is likely, then, that cues of fatigue might also affect interindividual behavior, such that a person displaying cues of fatigue might be treated differently than someone appearing well rested. This finding has potential implications related to perceived attractiveness and partner interactions. In fact, the desire to look less fatigued is one of the primary motivators for undergoing cosmetic surgery.[14] Importantly, such cues might also affect more professional settings, such as at the workplace, and in patient-health care provider interactions, in which cues of fatigue might divert attention from the task at hand.

Our results show that fatigue ratings are strongly related to cues that pertain to the eyes. This is also supported by previous studies on sleepiness[7] and fatigue,[8] showing that eye-related behaviors are indicative of sleepiness and that one looks to the eyes to evaluate fatigue. The value of the eyes as cues for fatigue is supported by studies on and methods for detecting driver sleepiness.[7] Whereas those studies focus on aspects of eye movements, such as blinking or eyelid closure,[15] we demonstrate here that static information is also of importance. Glazed eyes was a characteristic significantly related to looking fatigued but not to sleep deprivation. Future studies are needed to investigate whether this cue is indeed affected by sleep.

In addition to characteristics of the eyes, skin appearance was used by observers to perceive fatigue in a face. The role of sleep in the appearance and function of the skin has received remarkably little attention, despite the fact that the skin is the largest organ of the body and there is a strong increase in skin blood flow during sleep.[16] The function of this increase is unknown, but has been suggested to support the barrier defense of the skin as part of the immune system.[17] Such a role for sleep in maintenance of the integrity of the skin is supported by the observation that skin lesions are among the first and most pronounced deficits in rats subjected to prolonged sleep deprivation.[18] Also, endothelial dysfunction has been found in patients with obstructive sleep apnea.[19] The mechanisms by which sleep deprivation causes pale skin, wrinkles, and dark circles under the eyes remain to be explored.

Droopy corners of the mouth signaled a fatigued appearance, whereas tense lips did not. Tense lips was a characteristic included as a control variable and was not expected to relate to looking fatigued. Droopy corners of the mouth is a characteristic that may also be suggestive of sadness, leading observers to make possibly incorrect conclusions about the sleep deprived individual's affective state. Considering that elicited emotional facial expressions are subdued when sleep deprived,[20] it is interesting that with a neutral facial expression, a fatigued appearance was related to looking more sad.

Research on emotion has described several intercultural effects on facial expressions[12] and this may also be the case for fatigue. Both observers and photographed individuals were Caucasian Swedes and future studies should elucidate whether these findings can be generalized to other ethnicities and cultures. All photographs were taken in a well-controlled laboratory setting, with instructions prompting a neutral facial expression, and it is likely that real-world perceptions are modified by a number of factors, such as makeup, lighting conditions, and movement, that may mask or amplify how we perceive other individuals' fatigue. Also, this study only manipulated sleep and future studies will have to investigate how factors such as stress, disease, and physical or mental exertion affect fatigue and facial cues.

Although the sleep deprived participants were not informed about what the photographs were for, it is possible that they expected them to be compared with the photographs taken at baseline. This may have encouraged them to express more fatigue when sleep deprived. However, it is unlikely that people would be able to control the appearance of most of the cues (e.g., red eyes, swollen eyes, dark circles under the eyes, pale skin, wrinkles, and fine lines). In addition, the purpose of the instructions was to standardize and to limit masking effects, but they may have caused a bias in the results by curtailing the natural expression of fatigue.

The effects of the included cues differ widely. The effects of sleep deprivation was larger than 10 mm (on a 100-mm VAS) for cues such as hanging eyelids, swollen eyes, droopy corners of the mouth, and sadness, whereas red eyes, dark circles under the eyes, and pale skin had effects closer to 3-7 mm. Future studies will have to investigate how we combine different cues when judging others' fatigue and the clinical relevance of the effects reported here. For example, when do we judge someone as too fatigued to carry out certain work tasks?

The goal of the current study was to evaluate which facial cues are related to sleep deprivation and fatigue and did not include questions on perceived sleepiness. There is thus a need for future studies to assess the relevant cues with regard to other definitions within these concepts. The distinction between fatigue, sleepiness, and tiredness has not been addressed in this study. Further studies might find that there is a difference between the cues of sleepiness and those of fatigue or tiredness. Although researchers often refer to sleepiness, tiredness, and fatigue as three distinctly different states, they are commonly used interchangeably by the general public, which is not surprising because these phenomena are similar in nature, have overlapping causes, and include a number of different conceptualizations and definitions.[4]

The study is limited to static facial cues and does not address whether dynamic cues, such as facial or bodily movements,

signal fatigue after suboptimal sleep. Examples of such dynamic cues are yawning, rubbing one's eyes, and reduced prosody.[21] Furthermore, all facial cues assessed (except for one control cue) had been suggested by sleep researchers and students to indicate fatigue. It would be interesting to see whether there are other aspects of the face affected by sleep deprivation and that make us look fatigued.

The current study included 23 analyses for the main hypotheses, suggesting a risk for type 1 errors. The sample size was limited to 20 photographs and 40 observers, but the large amount of ratings (close to 800 for each cue) allowed us to reduce the risk by setting the significance level to 0.01 without substantially compromising power. The finding that the same cues that related to fatigue also related to sleep deprivation (with the exception of glazed eyes) suggests a good compromise between power and risk for mass significance. The large amount of analyses on the individual level (each of the 10 photographed individuals was analyzed with respect to 12 aspects) were included to illustrate possible response patterns of how individuals were affected by sleep deprivation on these facial cues. For example, hanging eyelids was the most common cue found in sleep deprived individuals, whereas no one had more glazed eyes. In addition, the separate *post hoc* analyses for men and women indicate similar effects in both sexes. The only main difference occurring when analyzed separately was that women were not perceived as significantly paler when sleep deprived, something that was significant for men and for the group as a whole.

Implications

The fact that many facial features are affected by sleep deprivation suggests an implication of these as cues in nonverbal social communication. In addition, it is possible that awareness and knowledge of such cues could improve detection of fatigue in safety sensitive operations. The study also suggests that individuals who express any of these cues of fatigue for other reasons (e.g., ptosis of the upper eyelids or in expressions of emotions) may mistakenly be perceived as being fatigued. Further studies will have to investigate how we perceive individuals showing contradictory cues simultaneously.

CONCLUSION

Human observers are sensitive to multiple facial cues that signal someone's sleep history. Integration of these static visual cues from the face seems important for estimations of others' level of fatigue. It would be worthwhile to investigate the mechanisms underlying these facial changes as well as their implications for social interaction, medical diagnoses, and safety situations.

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DISCLOSURE STATEMENT

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